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Metering Strategies for NEPA

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1 Executive Summary

Metering needs urgent attention in NEPA as less than 30% customers have a working meter. Only a portion of the electricity delivered to a Zone is billed to the customers. Inadequate metering is the major contributing factor for poor collection ratio. Meter reading process needs revamping; but meter readers cannot be blamed for all the problems as there are very few working meters.

NEPA needs to find a way to procure 2 to 3 million meters on high priority to improve the company's most critical problem – low collection. This program should be prioritized ahead of other capital programs that are aimed at improving supply.

The following serious issues require urgent management attention:

- There are no meters for 30% of customers.
- 50% of installed meters are defective.
- Meters are not read correctly/regularly.
- Inefficient and outdated mechanical meters are still being procured.
- New connections are given without installing meters.
- Cost of meters collected from customers; but not passed on to meter manufacturer.
- Customers deposit the cost of meters; but not passed on to Meter Manufacturer.
- Meter Manufacturer (monopoly) starts production only after receipt of full cost of the meter.
- Average 12 to 18 months waiting period for meters after giving connections without meters.
- Customers billed on estimated basis which give rise to disputes and malpractices.
- Meter maintenance charge levied from customers for meters that are yet to be installed (@ N500 per month).
- Meter cost levied from customers is too high: N6500 for single phase mechanical meters, where as modern digital electronic meters are available in international market at N1500-1800; Similarly the cost of Circuit Breaker in the market is N600-800 where as N4600 is levied from customers.

- Average customer pays N6500 towards cost of meter and N9000 towards meter maintenance charges (500x 18 months) before their meters are installed.

Metering today is not limited to revenue collection but has expanded into areas of outage management, load control, system planning, tariff structuring, reduction in T&D losses, etc.

This report examines in detail the metering practices in NEPA, presents a brief account of the state of the art for metering technology including Automated Meter Reading Technologies (AMR) and Smart Card operated Prepaid Meters. The report offers the following key recommendations on the most pressing issues faced by NEPA on the metering front:

Issues	Recommendations
Meter Ownership	• All MD Meters may be owned by the Customer; NEPA may procure, install and maintain • All Non-MD Meters may be owned by NEPA; Collect refundable security deposit from customer; Charge reasonable monthly meter rent; NEPA to stock meters in all field units
Type of Meters	• Stop using Mechanical Meters • Procure AMR meters for MD customers (fixed network with telephone dialup modem) • Procure digital electronic meters (capable of migration to AMR / Prepaid) for all Non-MD customers • Appoint a metering consultant to undertake detailed countrywide studies to formulate comprehensive metering strategies, select appropriate technology and areas where AMR and prepaid can be introduced in a phased manner
Procurement Procedure	• Type of meters may be finalized and tentative cost estimate prepared after ascertaining the prices from several manufactures (check websites / price lists etc) • All meters may be procured through international competitive bidding • Tender notices to be published in international media and bids to be accepted only from manufacturers
Meter Stockpile	• NEPA should stockpile enough meters that all new connections are given only after installation of meters

Cost	• Average cost of single phase digital electronic meter in international market is US$ 10-12 • In China digital electronic meters are sold under US$ 5
Billing Software	• NEPA to buy a modern billing and cash management software running on windows operating system urgently
100% Metering as Corporate Policy	• NEPA to issue a policy document stating that (a) 100% connections to be metered; (b) All connections with out meters will be provided meters within XX months; (c) All defective meters will be replaced within XX months; (d) No more new connections will be given without meters after a set date.
Financing	• Procurement of MD meters to be funded by the customer • Arrange commercial loans and/or development bank loans for procurement of meters and stock the meters; suppliers credit may be negotiated where ever possible • Use meter deposit and meter rent for servicing meter procurement loans • Explore possibilities of engaging Metering Contractors who are willing to invest and maintain the meters in return of a share of the revenue
Meter Reading Practices	• Continue with the existing NEPA employees; Do not recruit fresh meter readers; Meters readers can be better utilized if they are brought under Distribution Maintenance Department • Meter Readers becoming redundant due to introduction of AMR/prepaid meters may be used for bill distribution etc till they retire • Engage contractors for meter reading and bill distribution wherever possible and economical • Train fresh employees in new types of meters • Solicit cooperation/help of Residents Associations, Voluntary Organizations, Student Bodies etc in meter reading and bill distribution where ever possible
Management of Connection Fees and Meter Maint Charges	• NEPA should develop a formalized system of reporting and monitoring the meter related collections and disbursements at the Districts, Zones and HQ.

2 Introduction

2.1 Project Background

USAID has contracted Nexant to provide technical assistance to NEPA on how to implement the transitional wholesale electricity market. [1] A component of the project addresses re-engineering core processes at the distribution and marketing divisions to instill commercial practices and create functionally independent DisCos to operate within the new market. This report presents the consultants' findings on retail metering.

The recommendations in this report have been developed based on discussions with NEPA Executive Directors, field managers, RCM contractors and HQ staff. Abuja Zone organized several key field trips and meetings for the consultants to better understand the situation on the ground.

2.2 Purpose of Report

NEPA urgently needs to address serious shortcomings in retail metering that are hampering the company's ability to collect its revenues. The purpose of this report is to identify the key issues, review the potential solutions and provide recommendations that altogether constitute a top-level retail metering strategy for the company. NEPA can use this report as a foundation for further refinement.

This report examines the metering practices in NEPA and modern metering practices at utility companies worldwide and recommends immediate steps that NEPA can adopt. The rest of this report is divided into the following sections:

- Section 3: Diagnostic of Current Metering Program – Identifies the key metering issues at NEPA.
- Section 4: Review of Modern Metering Technology – Examines state-of-the-art retail metering technologies that NEPA should consider for its metering program.
- Section 5: Options and Recommendations for NEPA – Identifies alternative solutions and provides recommendations.
- Appendix A: Automated Meter Reading State-of-the-Art – Provides an introduction to AMR.

[1] See the report *Financial Autonomy for NEPA New Business Units* (Nexant, Sep 2003).

- Appendix B: Retail Metering Case Studies – Reviews relevant international case studies of prepaid metering programs and AMR.
- Appendix C: Transforming Meter Data into Knowledge – Reviews state-of-the-art meter data information systems.

2.3 Overview of Retail Metering

The energy meter is the cash register of an electricity utility. The accuracy of the meters determines the accuracy of recorded revenue. The modern energy meters can capture and store a tremendous amount of data, which can be a goldmine that brings additional revenues to the utility through integrated meter data management solutions.

Over the years metering has served primarily as the means to track consumption. Metering today is not limited to revenue collection but has expanded into areas of load control, system planning, tariff structuring, reduction in T&D losses, etc. An integrated system approach is needed for metering to achieve these applications. A combination of state-of-art in metering and information technology can provide an integrated solution to many problems faced by utilities.

During the past 10 years, the metering industry has made rapid technological progress that has not only enhanced the functionality and utility of meters, but also reduced the cost of the meter itself. The cost of Automated Meter Reading (AMR) systems has come down so drastically that utilities in developing countries are also adopting these technologies. With capabilities for load profiling, outage management and distribution planning, the two-way AMR can do many functions that a distribution SCADA scheme can provide.

The fast progressing sectors in the metering arena are the Fixed Network AMR and Pre-Paid Meters. Several competing technological standards exist in the market. Unless proper care is exercised while selecting the most suitable products, the vendor-driven market conditions will push the utility to adopt standards that may go obsolete in few years time. This is a scenario that developing countries like Nigeria can ill-afford.

3 Diagnostic of Retail Metering at NEPA

Quantification, measurement and invoicing are the core activities in the commercial enterprise. NEPA has around 4.12 million customers of which above 1.3 million have no energy meters! About 50% of the 2.82 million meters are believed to be faulty. Following the appointment of the Revenue Cycle Management (RCM) Contractor in Abuja District, more than 50,000 new connections were given in the past 18 months; but almost all connections were given without meters. This is despite the fact that all of these new customers have deposited the cost of meters prior to getting their connections.

Energy meters are standard products readily available everywhere in the world. There are suppliers in many countries that can produce hundreds of thousands of energy meters in a month. In 2002, Chinese companies alone shipped more than 6 million digital electronic meters. Internationally the average cost of a single phase digital energy meter with 15 years guarantee is only around US$ 10 – 12 (N 1400 – 1700). NEPA charges N 6500 towards the cost of a single phase meter and N 4600 for a circuit breaker (which is available under $5 anywhere) from their customers.

The actual reason why NEPA is unable to procure sufficient meters even though the customers pay in advance is enigmatic.

3.1 Types of Meters Used

Energy meters have been used from the late 19th century. First meters operated on liquid movements, analogous to sand watch. These were replaced by mechanical meters, surviving without major changes for more than 100 years. Mechanical meters are obsolete in today's electronic, highly computerized environment. The digital meter is preferred for measuring electricity production and distribution, and in the customer service and payment processing arena.

However NEPA still continues to use the mechanical meters of Class 2 accuracy. The major problems with these types of meters are:

- Class 2 compliance is often a fiction. Mechanical meters are tested at factory but lose their tune-up during transportation. After a few years in operation, any reasonable accuracy is lost. Though need for testing after 10-year operation is usually specified, there is no

practical way to tune-up installed meters. As a result, accuracy of 12-year-old mechanical meters is often in 5-8% range.

- Mechanical meters could easily be tampered with. Reverse connection, high-frequency coil saturation, magnetic or weight disturbance of measuring disk, holding the disk are all well-known methods for customers to defraud distribution companies. With delayed reading, it is almost impossible to detect consumption anomaly. There are even books available with titles "STOPPING POWER METERS" in the market that customers can buy and master the art!

Some utilities tend to believe that the errors in these meters go in the utility's advantage, hence they resist the change over to electronic meters.

The major categories of meters used in NEPA are:

- Maximum Demand (MD) Meters (for C& I customers of 100 KW and above)
- Non-MD Single Phase Meters
- Non-MD Three Phase Meters

There are only 26,000 of maximum demand customers in NEPA. Non-MD customers (single phase & three phases) are around 4.12 million.

There are a few pilot projects for pre-paid meters (in Lagos, Abuja & Kano) and electronic meters in progress.

3.2 Meter Procurement Process

Historically NEPA buys all meters from a domestic meter manufacturer (EMCON) that was partly owned by NEPA and that has recently been privatized. The technical specifications for meters are verified by NEPA. NEPA has been exploring other international sources for meters and the Federal Government has negotiated an MOU with the Government of China to build a meter manufacturing plant in Nigeria; however EMCON remains as the sole supplier for now.

The process of procurement is not streamlined and is left at the discretion of Zonal Managers. As a policy, NEPA does not believe in stocking of meters. The policy is to place an order for meters only when a customer deposits the price of the meter. This price is determined by NEPA and the monopoly meter manufacturer.

Once the NEPA Zonal Office collects the meter cost from the customer, they place the order for meters with the meter manufacturer. It is reported that the manufacturer waits until payment is received before starting production. Once the payment receipt is confirmed, they produce the meters and send them to NEPA's Meter Testing Unit for calibration and testing. Thereafter the meters are dispatched to the Zonal Office and from there it is allocated to the respective Districts.

In an ideal situation this process takes 2-3 months after a customer deposits the money; but in practice it takes more than 12 months. Such inefficient and unsatisfactory system of procurement for a simple off-the shelf product is highly unusual.

Zones collect the connection charge; HQ accumulates the meter maintenance charge. In total, this should be more than sufficient to buy adequate meters. Where the money is going? This indicates weak financial controls of meter related collection and disbursements.

Since the customer has deposited the money and it is NEPA's responsibility to deliver the meter, the customer has no responsibility on the delay in procuring the meter. Hence NEPA agrees to give a provisional electricity connection without a meter. The consumption for monthly billing is estimated by the NEPA officials based on the connected load in the premises and the usage pattern. Regular monthly bills are issued to the customer, based on the estimated consumption until meter is installed.

This gives rise to a number of problems such as:

- Customer does not agree with the estimated consumption and they complain that most of the time there is no electricity and hence NEPA can not charge as estimated.
- Dishonest customers without meter give electricity to their neighbors etc as they are in any case billed for the estimated units only.
- The local NEPA officials enjoy discretionary powers in estimating the expected consumption, which can be misused either to the advantage or disadvantage of NEPA.
- Since the origin of such discretionary powers is the delay in procurement of meters, stakeholders may try to further delay the process of meter delivery and installation.

3.3 Replacement of Defective Meters

There are no reliable statistics available about the number of defective meters in use. It is believed that at least one third of the meters are not in working condition.

NEPA charges N500 every month from residential (single phase) customers towards meter maintenance charges. This amount is remitted to HQ along with other tariff revenues. In practice, this money is not returned to Zones to be used for meters.

It is believed that more than 50% of meters are defective; however no concrete program for replacement of defective meters is in place. The back-log of meters for new connections itself is increasing.

Utilities in certain countries charge a meter deposit (almost equivalent to the cost of the meter) and give a meter to the customer. A meter rent is collected every month in the bill. Here in principle the ownership of the meter rests with the utility. Hence the utility replaces it when it is defective. The meter deposit is refunded to the customer when they surrender the electricity connection.

In some other countries the meter is owned by the customer. The utility specifies the type of meters and certifies meters that are approved, which a customer can directly buy from the manufacturer/dealers/shops. Customer must get these meters tested at the utility's testing station before installation. In this scheme, the responsibility to replace the meter when it is defective rest with the customer. The utility does not charge any meter rent or meter maintenance fee.

NEPA charges a re-connection fee (N 1500) to customers who were disconnected due to non-payment, theft etc. This money does not come into the accounts of NEPA HQ and is used at the District level. 10% of the reconnection fee is distributed to Marketing Staff as incentive.

3.4 Cost of Meters

The following table shows the meter-related charges to NEPA customers:

Type of Meter	Cost of Meter	Cost of Circuit Breakers	Cost of Other Items (PVC etc)	Total for a New Connection
Non-MD: Single Phase	6500 + 5% VAT	4600 + 5% VAT	5500 + 5% VAT	17,430
Non-MD: Three Phases	18500 +5% VAT	3 x 4600 + 5% VAT	11,000 + 5% VAT	45,465
MD Meter	CT Operated Meters : N 110,775			
	Whole Current MD Meters : N 67,725			

As mentioned earlier, the cost of a single phase digital energy meter is in the range of Naira 1400 to 1700 only. Electromechanical meters are also available in the international market at prices below US$ 10. Similar makes of circuit breakers are available at N 600 - 800 in Nigeria.

It is reported that the entire money collected by NEPA towards the cost of meter and circuit breaker is transferred to the meter manufacturer. NEPA does not keep any margin.

3.5 Monopoly Supplier

The acute shortage or inefficiency in the metering program originates from the fact that there is only one manufacturer, which was again part of NEPA till very recently.

In the old days, most utilities around the world had such monopolistic meter suppliers, which were partly or fully owned by the utility or its government. However in most such countries the governments and utilities have stopped supporting inefficient producers and have either resorted to meter procurement through public tenders or shifted the onus to the customers to procure meters from the market. This has helped not only the utilities and customers, but also the old monopolistic meter manufacturers, who in the changed circumstances have to compete with other producers. There are many examples where meter manufacturers who were enjoying government support and monopoly, but still making losses, have tremendously improved their performance after the introduction of competition.

If meter manufacturing in Nigeria is a nonviable business that cannot sustain on its own if open to competition, then by trying to support a nonviable business unit, NEPA is losing several times more money (un-

metered connections due to non-availability of meters) every month than the annual business volume of the meter manufacturer

3.6 Prepaid Meters

NEPA started a pilot project of installing Pre-Paid Meters in Lagos in 1997. Six years later it is still remaining as a pilot project, except that a few more prepaid meters have been installed in Abuja and Kano as extension of this program.

For comparison, during the period between 1992 and 2002, ESKOM installed 2.6 million pre-paid meters in South Africa (see case study in Appendix B). Incidentally, the company that started the NEPA pilot program in 1997 is CONLOG of South Africa in collaboration with ESKOM. Why this scheme could not take-off in six years in Nigeria is a mystery.

Total pre-paid meters installed till now are: Lagos – 2000; Abuja – 700 and Kano – 1000. As part of the new initiatives, some digital electronic meters and some Chinese make pre-paid meters (smart card type) are under testing at various field units.

It is reported that in Lagos where the prepaid meters are in use for last 6 years, customer reaction has been very positive. However hardware and software related complaints are frequent. It is also reported that many customers have mastered the art of by-passing the pre-paid meters already.

It is understood that the Government of Nigeria has signed a memorandum of understanding with a Chinese meter manufacturer to produce 3 million prepaid meters in Nigeria. This requires detailed studies for the following reasons:

- The entire country cannot be run with prepaid meters; it is not practical.
- Manufacturing of prepaid meters may not be economically viable in Nigeria as the electronic components that account for 70% of the cost will have to be imported; hence local value addition will be nominal.
- Monopoly supplier can drive the cost of meters up.
- Getting locked-up with one technology can lead to producing outdated meters after a few years. Technological transfer for

product up gradation can be expensive. Many developing countries have learned this at high costs in several sectors of manufacturing.

Before NEPA or the Government proceed with local manufacturing of prepaid meters, it would be prudent to undertake a detailed study with the help of a metering expert.

4 Review of Modern Metering Technology

Metering technology has advanced dramatically in recent years and utilities that have adopted appropriate integrated metering and meter data management systems have started reaping the benefits.

A brief description of various products and technologies that are in use today and their major advantages are presented in this chapter. A more detailed account of automatic meter reading (AMR) is provided in Appendix A.

4.1 Electronic Meters

Electronic kWh meters are gaining acceptance worldwide, while the electromechanical meter is losing ground at increasing speed. Electronic meters offer many advantages, such as higher accuracy across a wider range, additional features at very little or no extra cost, and smaller size.

Electronic energy meters have been in use for a long time, initially in the analog form with stepper motor counters. The features of a modern electronic meter can be divided into two major functions – the metering circuit and the feature part. The feature part is usually based on a standard micro-controller. The metering section calculates the power consumption from the voltage and current values supplied to the load. The current information is usually taken through a 'current sensor', which is often a shunt resistor or a current transformer or a Hall sensor-based element. The voltage information is usually taken from the mains voltage through a voltage divider. The calculated power is integrated over time, which then represents the energy consumed.

The analogue meter circuits were based on discrete components solutions. Most were based on time division multiplication. Its output is not synchronized to a clock or a crystal but it continuously calculates the product of current and voltage. Analogue meters lack stability and are reported to drift in their accuracies over long period of usage when installed in regions prone to large fluctuations in temperature. Analogue meters cannot capture and provide the kinds of data that are required for energy management decisions.

Digital energy meters using digital signal processing (DSP) technology have the ability to capture, process and present energy usage data in various forms and also offer the most cost effective solution (as low as a

good electromechanical meter) to utility metering. An analogue to digital converter (ADC) samples current and voltage transducer output at a high frequency, translating real world wave form to binary digits for the digital circuitry. Once converted to digital signal, the voltage and current wave forms can be multiplied, filtered and integrated by digital circuits to extract just about any information. A fixed function DSP places values in registers that can be read by low band width microprocessors. Applications requiring intensive calculations to continuously monitor power quality etc deploy programmable DSPs.

Fully electronic meters consist of the metering electronics and a micro-controller, which usually drives an LCD display. The cheapest range of digital meters is again built with stepper motor counters as electronic display requires non-volatile memory, which is still expensive and can drive up the cost of a meter by a few dollars. A stepper motor in a digital meter is exposed only to the low voltages from the integrated circuit's driving pulses and hence considered to be more reliable. Moreover in countries where meter reading is still manual and is prone to frequent power outages stepper motor counters is the preferred option.

Some of the advantages of electronic meters are:

- Electronic meters function accurately for wide current and frequency range (8mA to 80 Amps) and can withstand extreme climatic conditions (temperatures from sub zero to above 70 degree Celsius and humidity above 90%).
- Accurate calculation of consumption: Real long-term accuracy is available with electronic meters.
- Electronic meters can be connected in network, just like computers: That gives enormous advantages in programming the meters. Utility can simultaneously change tariffs, peak time, maximum consumption, overload features, set time, and perform testing of all meters, or set of meters in any given area. Software upgrades can be downloaded to the meters to comply with changing requirements.
- Automated reading: All electronic meters can be equipped with AMR modules which will enable these meters to be read remotely in real time or at any scheduled intervals.
- Prepaid capabilities: Electronic meters can be upgraded to prepaid meters.

- Multi-Tariff or Time of Use charge capabilities: Electronic meters not only allow multi-tariffs, but they also could be changed at any time. This opens way to sophisticated consumption management. Facing higher peak-time tariff, many customers will reduce their consumption during overload. Lower nighttime tariff will help many manufacturing companies by reducing their costs.
- Electronic meters consume very less power: IEC 1036 standards allow 2W of active power consumption and 10VA of reactive power consumption for energy meters. But modern digital meters consume less than 0.2W.
- No wear and tear or accuracy deterioration: Solid-state integrated circuit electronics ensures accuracy for very long periods; No need for recalibration or scheduled tests. No need for maintenance. High resistance to heat, moisture and dust; Normal lifespan of 20 to 30 years. Software and hardware upgrades are possible.
- Reverse flow measurement capabilities: Meters can be equipped with ability to calculate the power even with reverse connection.
- Advanced features of some of the meters include power quality analyzing, maximum demand stream data, power factor, energy loss etc.

4.2 Automated Meter Reading Technologies

Automated Meter Reading (AMR) was introduced in North America to read difficult-to-read meters placed at inaccessible locations and hazardous –to-access meters. It was a costly solution in the early nineties. However with rapid advancements in technology, the cost of AMR started falling and the utilities that went in for these technologies have realized that AMR can deliver much more value than mere meter reads for billing. Utility management is beginning to appreciate the big-picture benefits of AMR. Many utilities are able to justify AMR investment solely on the basis of the intelligence it brings to strategic and tactical decision making. The emerging benefits of AMR include distribution planning, outage management, supply and load management, load forecasting, energy diversion, call center operations and credit and collections.

At the heart of any AMR is a small electronic device called ERT module. This ERT (Encoder, Receiver and Transmitter) unit can be integrated with any electronic meters. There are various means of collecting the meter data from these ERT modules.

AMR is broadly classified in to Mobile AMR and Fixed Network AMR. In the mobile scheme a vehicle equipped with radio device and computer when driven around the locality where meters are installed, communicate with the ERT module in the meters and the meter data is downloaded over RF frequency.

Fixed Network AMR is a two-way communication scheme where a group of meters in one locality communicates with a Concentrator or Cell Control Unit (CCU) installed in the vicinity. A group of CCUs are connected to a Network Control Node (NCN) in the area, which acts like a router in the network, and the NCNs are connected to a host computer. There are different communication platforms that exist for the communications between ERTs, CCUs, NCNs and the host computer. RF technology utilizing the 900 MHz unlicensed spectrum is the market leader. New technologies using PSTN (public switched telephone network) both wireless and hard wired, power line communication (PLC), Internet and satellite are also gaining popularity. Mobile networks can be converted to fixed networks.

AMR has the following advantages:

- Network Optimization and Asset Utilization Improvements
- Outage Detection & Restoration Notification
- Load Profiling and Forecasting
- Monitoring Power Quality & Reliability
- Remote connect/disconnect services, tracking of meter tampering etc are also possible through two way AMR systems.

4.3 Meter Data Management

Software systems that collect, analyze and manage metering data, and present it in some usable form is the critical part of the entire metering system. Some examples of applications that are being developed include those that take granular, real-time information and use it for distribution planning, outage management, load profiling & forecasting, load and supply management etc.

Meter data management is the fastest growing segment in the utility software industry today. Many new applications are being developed. Examples include home automation using the meter as the gateway to switch on and off appliances as air-conditioners, heaters and other

appliances. Utilities wanting to improve customer service may even promote packages of services. For example, a utility might offer a basic package with monthly meter reading, and could offer other information that would be sold to customers. If a customer wants more detailed bill, wants to know hourly what usage looks like or to know how his daily consumption compares with others, the utility can offer those information services for a premium. Most commercial and industrial customers would like to get such information for benchmarking.

Utilities using meter data to other applications are not only optimizing their peak load-supply balances but also enabling the customers to manage their energy (or water) consumption. Basically the meter data is being used to manage the commodity; not just for metering and billing. See Appendix C: Transforming Meter Data in to Knowledge.

4.4 Prepaid Meters

Prepaid metering in its simplest form refers to paying for electricity, gas or water before it is used. The consumer purchases credit and then uses the resource until the credit expires. The concept of prepaid metering is not new, having first been introduced in the form of coin gas meters in the United Kingdom well before World War II. Major change took place in the 1980s when electronic or numeric transfer of the credit was introduced.

A traditional electronic prepaid metering system operates on three levels. First are the meters, which are installed at the consumer's home. The next level is the vending stations, situated at the utility's offices or at appointed agents. The communication between the vending stations and the meters is in the form of a token, which is used to top up the credit in the meter. Tokens also transfer or download information to the meter, and in some cases upload information (depending on the token choice) back to the vending station.

At the top level is the System Master Station (SMS) or master client, which is necessary to ensure a common database for reporting and to provide total management, administration, financial and engineering control. The SMS communicates with the various vending stations via modem or other data link. Information on consumers, tariff changes and so on is communicated to the vending station and detailed customer sales are communicated back up to the SMS.

There are a number of reasons why a utility could consider installing a prepaid metering system. They include improved cash flow, no need for account posting or additional billing processes, elimination of bad debts, elimination of disconnection and reconnection fees, ease of installation, no need to access consumers' property and elimination of inaccurate meter readings.

There are also advantages to the customer, including budget management, control of energy usage, no cost for disconnection/reconnection and no waiting for reconnection, no deposits and the ability to pay back debts.

Prepaid energy meters using keypad based systems, disposable card systems (one-way) and two-way smart card systems are in use in various parts of the world for over a decade.

4.4.1 Keypad Operated Prepaid Meters

In the early nineties prepaid energy meters came with keypad systems for inputting the credit instead of smart cards. Security of keypad payment system is very low. The main reason is that the algorithm of key creation is stored inside the meter and is available to hackers. Keypad systems were created when highly secure smart card payments did not exist.

Although keypad systems are getting obsolete, it may still be cost-effective for remote villages, where two-way vending may not be feasible.

4.4.2 Smart Card Operated Prepaid Meters

With Smart Card operated system, customers purchase a reusable power debit card for the amount of energy they desire. These special, easy to use cards are individualized, keyed to each customer's meter and account number. The customer simply passes the card a few inches in front of the meter, and using an integrated card reader, the meter is reset to the number of kilowatt-hours contained on the card. The system works very much like a bank debit card. Because the meter is completely sealed and has no moving parts, maintenance is reduced and reliability is improved. Modern Smart Card operated meters are "stand alone", requiring no separate in-house keypad or onsite programming. The card captures transaction and power usage information, sending automatic input into the utility's accounting system at the sales terminal each time the customer purchases additional power. The card also captures data critical for load forecasting.

Disposable card type prepaid meters are also in use in certain utilities. The vending infrastructure for this scheme is much simpler, but it does not offer the advantage of capturing customer's usage data.

In regions with high-humidity or very dusty environment contact-type card readers may lose their reliability. In such conditions, contact-less type rechargeable cards are used.

4.4.3 Prepaid Meter using two-way fixed network AMR

Meters installed with real-time two-way communication facility, the transaction data is stored on central computer and authorized in the same manner as for credit card terminals. Here security is not at risk as the credit information is stored on the central computer.

A more detailed account of prepaid meters, experience of utilities around the world with prepaid meters and a successful implementation methodology for prepaid vending system are given in Appendix B.

4.4.4 Social Issues for Prepaid Meters

Automatic service interruption has always been an integral part of prepaid electric service. But over the years electric service came to be regarded as a right more than a privilege in every society and hence regulators and law makers have found it difficult to accept the automatic disconnection feature of the prepaid meters.

In the USA, regulatory rules evolved to protect customers of investor-owned utilities from service interruption. Before terminating service to a customer whose payment is seriously past due, the utility must pursue an array of measures to secure payment. Prepaid electric service with automatic disconnection when the prepayment runs out is incompatible with the protective measures, and as a result only a few thousand customers are being served through prepaid metering in the US, mostly in municipal and cooperative utilities. Where as in UK more than 3 million prepaid electricity meters are in use today. ESKOM has installed about 2.6 million key pad type prepaid meters in South Africa during the past 10 years.

Widespread concern exists about the growing use of pre-paid water and electricity meters by private companies and governments. The meters are considered efficient and cost-effective for companies, which experience no lost revenue because users are cut off when they use all the credit they

have paid for. But the public health impact of prepaid meters, particularly prepaid water meters can be devastating.

In some countries there have been protests against use of prepaid meters. Pre-paid water meters were declared illegal in the United Kingdom (U.K.) under the U.K. Water Act of 1998 after water cut-offs were linked to increased cases of dysentery and other diseases related to lack of clean water. Being efficient on one end only leads to a backlog of expenses on the other end when people who can't afford clean water get sick from drinking dirty water and then seek services at public health clinics.

In tropical countries like Nigeria, ethical issues in use of prepaid electricity meters should not be treated as an injustice to the society at this stage of development. However, caution may be exercised while choosing areas for deployment of prepaid meters.

5 Options and Recommendations for NEPA

First and foremost, **NEPA should adopt a firm policy for 100% metering**. NEPA should issue a policy document stating the following: a) 100% of connections are to be metered; b) all connections without meters will be provided with meters by a set date; c) all defective meters will be replaced within a set timeframe; d) no more new connections will be given without meters after a set date.

Other major issues requiring policy decisions are:

- Meter Ownership
- Type of Meters
- Procurement Procedure
- Financing New Meters
- Financial Management of meter fees and charges
- Meter Reading Practices

The pros and cons of various options to address each of these issues are examined in the following sections.

5.1 Who Should Own the Meters?

Ownership	Pros	Cons
NEPA	• Easy to set standards • Better prices on bulk purchase • Better control on entire metering program • Ownership of meter data • NEPA can levy meter rent/maintenance charge	• NEPA needs to fund procurement • NEPA (Owner) should replace the damaged meters
Customer	• Customer can buy one of the make approved by NEPA from any vendor • Customer pays for meter • Connections given only after meter is installed • Customer pays for replacement of defective meters	• NEPA loses meter rent • Several makes of meters will penetrate the market unless proper controls in place • Need to create additional meter test stations to test the meters procured by customers

Metering Contractor	• Responsibility of meter procurement and installation is passed on to an expert agency • They can arrange funding	• Difficult to find an agency willing to invest

Recommendations:

- All MD Meters may be owned by the Customer; NEPA may procure, install and maintain.
- All Non-MD Meters may be owned by NEPA; Collect refundable security deposit from customer; Charge reasonable monthly meter rent; NEPA to stock meters in all field units.

5.2 What Type of Meters Should be Used?

Type of Meters	Pros	Cons
Mechanical	• Can continue with existing policies and practices	• Outdated technology, low accuracy • Prone to human errors in meter data capture • Large number of meter readers required • Can be easily tampered
Electronic	• High level of accuracy • Cheaper than mechanical meters if procured through international competitive bidding • Large numbers can be procured and installed in short period • Can be upgraded to AMR/Prepaid • Tamper proof • No training required for Meter Readers	• To be imported • Prone to human errors in meter data capture • Large number of meter readers required

Electronic with AMR	• Meter data can be captured accurately • Fixed network AMR enables outage management • Many other applications can be developed from the meter data • Enables time – of – use tariff, merit order dispatch, demand side management, load balancing etc • Tamper proof	• Different technologies are fast developing; hence a utility must carefully choose one that is most appropriate for it • Bigger investment to be made in upgrading backend computer systems, billing software, communication system etc • Employees need training
Prepaid	• Improves utility's cash flow • Meter reading, billing and collection expenses are reduced • Customer usage data can be used for load research, distribution planning etc • Good method to deal with delinquent customers • Tamper proof	• Large vending network to be created • People (customer, employees, vending agents) to be trained • People may resist • Regulatory and ethical issues to be considered

Recommendations:

- Stop using Mechanical Meters
- Procure AMR meters for MD customers (fixed network with telephone dialup modem)
- Procure digital electronic meters (capable of migration to AMR / Prepaid) for all Non-MD customers
- Appoint a metering consultant to undertake detailed countrywide studies to formulate comprehensive metering strategies, select appropriate technology and areas where AMR and prepaid can be introduced in a phased manner.

5.3 How Should Meters be Procured?

Options	Pros	Cons
Buy from Domestic Vendors	• Local availability • Savings in foreign exchange	• No domestic manufacturers for electronic meters • Cost may be high due to monopoly
Buy from a Foreign Manufacturer who will setup manufacturing facilities in Nigeria	• Local availability • Warranties can be ensured faster • Local employment creation	• Local manufacturing may not be cost effective due to low volumes • In electronic meters 70% cost is that of electronic components which in any case has to be imported • Can get locked-in with a technology that may go obsolete and the local unit will continue to produce outdated meters • Prices can be high due to monopoly
Buy through International Competitive Bids	• Best option to get good quality product at competitive rates • Faster supplies from large manufacturers • Can go in for latest products any point of time	• No internal capacity in NEPA to finalize specifications, inspection etc – require consultants • Financing to be arranged by NEPA • Conditions of contracts to be carefully drawn to enforce warranties

Recommendations:

- All meters may be procured through international competitive bidding
- Tender notices to be published in international media and bids to be accepted only from manufacturers
- Type of meters may be finalized and tentative cost estimate prepared after ascertaining the prices from several manufactures (check websites / price lists etc) prior to invitation of bids.

5.4 Should Meters be Stockpiled?

Options	Pros	Cons
Yes	• Likely to improve collections • Entire metering program can be planned and controlled • All connections given after meters installed • Can procure large number of meters at economic prices • Consumers are happy	• NEPA needs to arrange finance to buy and stockpile meters
No	• Meters are ordered after customer applies for it • No financial burden on NEPA	• Always shortage of meters • New connections without meters • No planned procurement actions can be taken in advance • Too expensive to buy from single manufacturer • Poor control on meter allocation and installation due to shortages

Recommendation:

NEPA should stockpile enough meters such that all new connections include installation of meters.

5.5 How Can Meter Reading Efficiency be Improved?

Options	Pros	Cons
Automated Meter Reading Practices	• Best solution	• Require large investments on meters and associated infrastructure • Large numbers of meter readers become redundant

Reduce Man-Meter interference	• Reading through hand-held devices can reduce human errors and ensure that the meter reader actually goes up to the meter	• Require large investments in hand-held devices and backend data transfer systems • Meter readers require training
Engage Meter Reading Contactors	• Will be cost effective to outsource this service locally in each area	• Existing meter readers becomes redundant • Require proper monitoring mechanism to prevent malpractices • NEPA to find money to pay the contractor
Use Prepaid Meters	• Ideal solution to solve meter reading related issues • Improves the cash-flow of NEPA	• The whole country can not be converted to prepaid regime • Require extensive network of vending facilities • Require training for customer, employees and vending agents
Associate Students, Voluntary Bodies, Residents Associations etc	• More economical than engaging contractors • Improved customer confidence and participation	• Require proper monitoring mechanism to prevent malpractices • NEPA to motivate the local bodies for better cooperation in return of higher levels of service

Recommendations:

- Continue with the existing NEPA employees; Do not recruit fresh meter readers. Meters readers can be better utilized if they are brought under the Distribution Maintenance Department.
- Those becoming redundant due to introduction of AMR and prepaid meters can be used for bill distribution etc till they retire.
- Engage contractors for meter reading and bill distribution where ever possible and economical.
- Train fresh employees in new types of meters.
- Solicit cooperation and help from residents associations, voluntary organizations, student bodies etc in meter reading and bill distribution wherever possible.

5.6 How to Finance Meter Procurement?

Options	Pros	Cons
Own Funds/Federal Funds	• Best option • Can procure faster • NEPA can levy meter rent which in the long run increases NEPA profitability	• Funds are not available
Customers to fund	• No financial burden on NEPA • NEPA can set the standards and Customers can buy or NEPA can procure and install	• NEPA loses the meter rent • Difficult to ensure proper utilization of money collected from customers towards meter cost
Loans from International lending agencies (IBRD, African Development Bank, Islamic Fund, Japanese Fund etc)	• Low interest loans with long term payback periods • Large sums can be borrowed • Easy to service the loans	• Procedural delays • Governments interference required at every stage • NEPA need to enhance internal capacity in procurement procedures prescribed by these lending agencies
Commercial loans from Banks(Domestic or Foreign)	• Faster to obtain • May not interfere with procurement process	• Difficult to service the loans • Interest rates higher • Difficult to convince the banks to lend money to NEPA

Recommendations:

- Procurement of MD meters to be funded by the customers.
- Arrange commercial loans for procurement of digital electronic meters to clear all backlogs and replace the defective meters; suppliers credit may be negotiated where ever possible.
- Use meter deposit and meter rent for servicing meter-related loans.
- Pursue loans from international lending agencies for migration to prepaid systems, AMR etc.

- Explore possibilities of engaging Metering Contractors who will invest in the metering program.

5.7 How to Install New Meters?

The following strategy is recommended to install the new meters:

- Appoint local contractors (3-4 agencies in each district) on annual contract basis who will undertake all meter installation work at a fixed rate per meter.
- NEPA and the meter manufacturer may provide basic training to the contractor's personnel and issue standard work procedure and checklists.
- Engage separate contractors to install meters at premises that have been given connections without meters; replacement of defective meters may be allotted to different contractors.
- While the meters are being installed, get the customer information data that will be required for the billing software.
- Installation of meters for new connections can be carried out by the existing staff of NEPA wherever possible, or can be outsourced to approved contractors.
- AMR and prepaid meters may be installed as per the directions of the vendor offering these solutions.

5.8 How to Improve Financial Management of Meter Charges?

NEPA should appoint a Special Task Force to investigate the financial management of meter fees and charges at the HQ, Zones and Districts. The Task Force will make recommendations on:

- Improved reporting and monitoring systems to manage meter charges.
- Improved treasury and banking practices.
- Formalized controls to be instituted at Zones and Districts.

5.9 Billing Software

NEPA urgently needs to buy a modern billing and cash management software package running on the windows operating system. Upgrading the existing billing software may not be the economically viable solution. This issue will be studied in detail in the next phase of the Nexant project.

5.10 Migration to AMR and Prepaid Meters

Several factors need to be studied in detail before adopting a particular technology or strategy for migration to higher levels of metering such as AMR and prepaid solutions. A solution that is viable for one utility may be inappropriate for another. Moreover, hybrid solutions using more than one technology often represent the best choice for a given situation.

In Africa several countries are using prepaid meters. The experiments in Cameroon and Zanzibar are reported to be great successes. Prepaid meters have been in use in Namibia for a long time. Sudan and Cote d'Ivoire have recently introduced prepaid meters. In South Africa ESKOM operates about 2.6 million prepaid meters. In the UK there are about 3 million prepaid energy meters in use.

The success of prepaid metering scheme depends to a very great degree on the thoroughness of the pre-planning phase. This includes seeking acceptance from both consumers and utility staff, and putting in place the necessary procedures for a smooth implementation.

Before embarking on a mass scale prepaid metering scheme a detailed study needs to be conducted by an expert who is not influenced by vendor driven technologies. A metering consultant should be appointed to study on-the-ground realities in Nigeria and formulate an appropriate strategy for migration to AMR and prepaid systems. The case studies given in Appendix B are relevant in this context.

In the meanwhile it would be advisable for NEPA to study various technologies available today and interact with different vendors and collect their opinions and offers. NEPA can organize a conference and discussion forum in Abuja where various vendors can present their products and services.

A detailed list of all major players in the advanced metering area who exhibited their products and services at the AMRA 2003 International Symposium (7-10 Sept 2003) in St.Louis, Missouri, USA can be found at www.amra-intl.org.

Appendix A: Automated Meter Reading State-of- the-Art

Automated Meter Reading and Prepaid Meters

1 Automated Meter Reading (AMR)

Automated Meter Reading (AMR) was introduced in North America to read difficult-to-read meters placed at inaccessible locations and hazardous –to-access meters. It was a costly solution in the early nineties. However with rapid advancements in technology, the cost of AMR started falling and the utilities that went in for these technologies have realized that AMR can deliver much more value than mere meter reads for billing. Utility management is beginning to appreciate the big-picture benefits of AMR. Many utilities are able to justify AMR investment solely on the basis of the intelligence it brings to strategic and tactical decision making. The emerging benefits of AMR include distribution planning, outage management, supply and load management, load forecasting, energy diversion, call center operations and credit and collections.

In North America alone about 10 million AMR units were installed in 2002. About 20% of total customers in North America (50 million customers) are served by AMR technologies today and this figure is estimated to reach 50% by the end of 2004.

At the heart of any AMR is a small electronic devise called ERT module. This ERT (Encoder, Receiver and Transmitter) unit can be integrated with any electronic meters. There are various means of collecting the meter data from these ERT modules.

AMR is broadly classified in to Mobile AMR and Fixed Network AMR. In the mobile scheme a vehicle equipped with radio devise and computer when driven around the locality where meters are installed, communicate with the ERT module in the meters and the meter data is downloaded over RF frequency. Fixed Network AMR is a two-way communication scheme where a group of meters in one locality communicates with a Concentrator or Cell Control Unit (CCU) installed in the vicinity. A group of CCUs are connected to a Network Control Node (NCN) in the area, which acts like a router in the network and the NCNs are connected to a host computer. There are different communication platforms exist for the communications between ERTs, CCUs, NCNs and the host computer. RF technology utilizing the 900 MHz unlicensed spectrum is

the market leader. New technologies using PSTN (public switched telephone network) both wireless and hard wired, power line communication (PLC), Internet and satellite are also gaining popularity. These are explained in detail below.

1.1 Mobile AMR

Mobile AMR uses vehicles equipped with radio units to read ERT module-equipped electric meters via radio without the need to access the meter. Mobile AMR dramatically improves meter reading efficiency.

A radio transceiver is installed in a utility vehicle. Route information is downloaded from the utility billing system and loaded into the radio transceiver. While driving along a meter reading route, the transceiver broadcasts a radio wake-up signal to all ERT meter modules within range and receives the ERT messages when they respond. Completed reads are uploaded to the billing system for bill generation.

Mobile AMR is usually used in saturated areas where there may be large populations, difficult-to-access, or hazardous-to-read meters. As a result of this level of saturation, meter reading efficiency is dramatically improved. A single transceiver reads an average of 10-12,000 meters in an 8-hour shift depending on meter density and system use.

Some of the advantages of mobile AMR are:

- The same radio transceiver can read electric, gas and water meter modules.
- Eliminates access problems
- Eliminates high-cost and hazardous-to-read meters
- Overall cost reductions
- Improved employee safety
- Improved meter reading and billing accuracy
- Theft identification
- Meet Performance-based Rate (PBR) criteria
- Improvements in Billing Complaints & Adjustments process
- Improved Customer Satisfaction

1.2 Fixed Network AMR

In a fixed network AMR scheme, the central host computer has two-way communication facility with the ERT modules in individual meters through the Concentrators and Network Control Nodes. The ERTs communicates over RF to the CCUs or over Ethernet (IP) or even uses a modem and a telephone line (cellular or land line) to establish a dialup connection to the host computer at set intervals and download the meter data.

Usually CCU is installed on power poles or street light arms. It is a neighborhood concentrator that reads meter modules, processes data into a variety of applications, stores data temporarily, and transports the data to the host processor when required.

The NCN is a regional concentrator and routing device that is installed in radio communication facilities, such as leased towers, substations or other communication facilities. The primary functions of the NCN are data transfer and information routing between CCUs and the host processor.

The Host Processor manages the collection of data from the network devices and facilitates the download of schedules and other application information to appropriate network devices. The host processor also transfers the data to a database for storage and retrieval.

The fixed network is usually installed over saturated areas where advanced metering data, variable reads and unscheduled reads are required. This saturated deployment spreads the cost of the network components over multiple meters.

Additional benefits of Fixed Network AMR include:

- Reductions in meter reading staff
- Improved accuracy
- Low-cost advanced meter reads (time-of-use, load profile, demand reads)
- Load profiling and load forecasting
- Outage Detection & Restoration Notification
- Improved system reliability
- Improved distribution system planning and asset management
- Delivery of new services to customers

- Accurate energy balancing and settlements transactions
- Energy Scheduling & Bidding
- Energy Imbalance Penalties
- Data Aggregation

Several technologies exist today for communication between the individual meters and the central host processor. Some of them are discussed below.

1.3 Telephone based AMR

Telephone based AMR uses telephone-based meter modules attached to electric or gas meters to communicate metering data, via telephone, to a central host processor.

Meters equipped with such modules are installed at the customer location and a telephone connection is installed between the meter and the telephone junction box. The existing telephone line at the customer premise can be used for communication between the meter and host processor, so no installation of dedicated phone lines to the meter is required. Most telephone-based technologies use "polite" technology to detect when the customer is using the phone line. The modules will not initiate calls or continue a call when the customer's phone line is in use.

Meter modules are programmed, from the host processor, to collect and store data in the module at scheduled times. The devices are also programmed to call into the host processor at pre-scheduled times. Communication to the host processor is usually scheduled during off-usage hours, such as the middle of the night. This also coincides with typical data processing timeframes of utilities.

Telephone-based solutions can be deployed when frequent reads or operations-oriented applications, such as outage detection and restoration reporting, are required.

Telephone-based systems are the most economically viable solution for rural, low-density or unsaturated deployments and C&I customers.

1.4 PLC based AMR

Power line carrier communication systems are familiar to all electricity utilities. PLC based AMR uses the same technology for communication

between ERTs, CCUs, NCNs and the host computer. Since the transmission of data is through the same electricity cables, additional wiring is not required. The bandwidth of PLC being narrow, there are limitations in the volume of data that can be pushed through PLC connection. However an ultra narrow band PLC based AMR is fast gaining market share.

1.5 Ethernet LAN based AMR

Due to low cost and industry-wide support, Ethernet has emerged as the most popular technology for LAN world wide. In buildings or campuses having Ethernet LANs, it is cheaper to use the existing LAN as a backbone for creating a sub-meter data highway, which will eliminate the use of modem and telephone lines. In such networks, Ethernet Data Accumulator connected to a group of meters (up to 9 or 10) is hooked up to the LAN and function as a hardware interface between the ERTs and the Ethernet LAN. The technology allows connecting all electrical, water, gas and steam meters in the premises. Hardware and software for Ethernet based AMR are available for both star and bus topology Ethernet LANs (particularly for 10Base-T and 10Base-2) and Fast Ethernet.

1.6 Hybrid Systems

The hybrid systems employing RF and telephone or PLC and Telephone etc are used as a low-cost metering solution.

ERT meter modules communicate with CCUs over RF or PLC. Concentrators gather information directly from ERT meter modules or through a series of Repeater Concentrators when direct communications to a particular ERT is difficult. The system then employs existing public telephone networks to send the gathered data from the Concentrator Units to the host computer. If desired, data can also be gathered from Concentrators using a Mobile AMR unit.

These types of AMR network is ideally suited for smaller clusters of meters that require more frequent reads, but where there are not enough meter points to effectively distribute the cost of fixed network infrastructure.

There are many examples where cellular phone operators have offered free airtime to utilities for communication between the concentrators and the host processor, in exchange for allowing the phone company to use

the electric poles for mounting their antennae, dedicated power to GSM base stations etc.

1.7 Advantages of AMR

1. Network Optimization and Asset Utilization Improvements: From daily, hourly or interval reads on applicable meters under a piece of equipment or from a selected portion of the distribution system, it is possible to determine the peak load by equipment or system section and move or replace improperly sized equipment accordingly. Also use the information for future infrastructure planning and build-out to ensure proper asset utilization. For many distribution utilities, the infrastructure that is in place to support peak loads is only 40-50 percent utilized.

Find the Weak Link in the Chain: Matching load data with outage data quickly reveals improperly rated or sized distribution equipment, which can then be replaced with properly sized equipment.

2. Outage Detection & Restoration Notification: Fixed Network AMR technology features immediate outage detection and restoration notification capabilities. Utilities are using AMR data for tracking outages, which not only can tell where outages are occurring, but also when the power is restored. Moreover, AMR data can allow utilities to prioritize outages - for example it can tell whether a single house is experiencing outage or an entire colony.
Outage response and restoration time is a key criterion for public utility commissions that are considering performance-based ratemaking packages for the utilities they regulate. Utilities that are able to minimize outages can reap the financial rewards of performance-based ratemaking.

3. Load Profiling and Forecasting: In order to maximize the distribution system efficiency, reliability and asset utilization, accurate energy usage by equipment or circuit needs to be determined. Accurate forecasting is also needed to determine if installed distribution equipment is adequate to handle the load, or is over-rated and therefore an "under-utilized" asset.

Based on AMR data a utility can understand when and why customers are using energy, so it can apply active load management programs.

4. Power Quality & Reliability: AMR data can be used to analyze power quality problems and improve overall power quality and reliability, especially for large commercial and industrial customers.

2 Prepaid Meters

Prepaid metering in its simplest form refers to paying for electricity, gas or water before it is used. The consumer purchases credit and then uses the resource until the credit expires.

A traditional electronic prepaid metering system operates on three levels. First are the meters, which are installed at the consumer's home. The next level is the vending stations, situated at the utility's offices or at appointed agents. The communication between the vending stations and the meters is in the form of a token, which is used to top up the credit in the meter. Tokens also transfer or download information to the meter, and in some cases upload information (depending on the token choice) back to the vending station. At the top level is the System Master Station (SMS) or master client, which is necessary to ensure a common database for reporting and to provide total management, administration, financial and engineering control. The SMS communicates with the various vending stations via modem or other data link. Information on consumers, tariff changes and so on is communicated to the vending station and detailed customer sales are communicated back up to the SMS.

The concept of prepaid metering is not new, having first been introduced in the form of coin gas meters in the United Kingdom well before World War II. Major change took place in the 1980s when electronic or numeric transfer of the credit was introduced

It would be interesting to see how prepayment has developed over the last 70 years from the primitive coin operated meter to the token-based systems and today's smart card operated systems.

Fixed Charge Collector – Hand-reset Type: This was the simplest form of prepayment metering, consisting of the meter and a switch. At each visit the meter reader removed the coins and tripped the meter's switch. The consumer re-closed the switch by inserting the requisite number of coins

Flat Rate Tariff Meter: In one form or other, this type of meter comprised the majority of the electricity prepaid meters in the UK for several decades until its replacement by its electronic token counterpart in the 1980s. Even today they are used by landlords as secondary metering.

Other types of prepaid electricity meters that were in use at different points of time include:

- Two-Part Tariff - Fixed Rate Type
- Two-Part Tariff - Variable Rate Type
- Double Tariff, Current Changeover Type
- Double Tariff, Time Change-Over Type

There are a number of reasons why a utility could consider installing a prepaid metering system. They include improved cash flow, no need for account posting or additional billing systems, elimination of bad debts, elimination of disconnection and reconnection fees, ease of installation, no need to access consumers' property (particularly for split meter installations) and elimination of inaccurate meter readings.

There are also advantages to the customer, including budget management, control of energy usage, no cost for disconnection/reconnection and no waiting for reconnection, no deposits and the ability to pay back debts.

Prepaid energy meters using keypad based systems, disposable card systems (one-way) and two-way smart card systems are in use in various parts of the world for over a decade.

2.1 Keypad Operated Prepaid Meters

In the early nineties prepaid energy meters came with keypad systems for inputting the credit instead of smart cards. Security of keypad payment system is very low. The main reason is that the algorithm of key creation is stored inside the meter and is available to hackers. Keypad systems were created when highly secure smart card payments did not exist.

Although keypad systems are getting obsolete, it may still be cost-effective for remote villages, where two-way vending may not be feasible.

2.2 Smart Card Operated Prepaid Meters

With Smart Card operated system, customers purchase a reusable power debit card for the amount of energy they desire. These special, easy to use cards are individualized, keyed to each customer's meter and account number. The customer simply passes the card a few inches in front of the meter, and using an integrated card reader, the meter is reset to the number of kilowatt-hours contained on the card. The system works very much like a bank debit card. Because the meter is completely sealed and has no moving parts, maintenance is reduced and reliability is improved. Modern Smart Card operated meters are "stand alone", requiring no

separate in-house keypad or onsite programming. The card captures transaction and power usage information, sending automatic input into the utility's accounting system at the sales terminal each time the customer purchases additional power. The card also captures data critical for load forecasting.

Disposable card type prepaid meters are also in use in certain utilities. The vending infrastructure for this scheme is much simpler, but it does not offer the advantage of capturing customer's usage data.

Smart card operated meters can be used either as prepaid or postpaid. In some countries, prepaid option is socially not acceptable. In such cases, each consumer is assigned 50-day credit. After each month, the consumer has to recharge a card to pay off his negative balance. After full payment, his 50-day credit is restored.
Credit can be time- or amount-based. Mixed option is also possible: 50-day but not more than X kWh.

Major features of Smart Card Operated Prepaid Meters are:

Detection of counterfeiting: Though security of smart card meters is extremely high, it is theoretically possible to break any card whatsoever, time being the only difference. It takes over a million hours to break the DES264 open-key random-base algorithm used in most smart cards (The same type of security is used for credit cards, electronic purses and GSM phones). Besides, such attempts will be easily detected by utility. Each card is assigned its own number. Central database contains information of all the issued numbers. After reading the meters, utility collects information on used card numbers.

Numbers of used cards are matched against central database of issued cards. Utility will immediately receive report on unauthorized cards and cards with restored balance. Because meter ID's are known to utility, it can detect and prosecute those using counterfeit cards.
It is impossible to use counterfeit cards and not to be caught after the first reading of meters without only physically breaking the meter. Locks can be provided against tampering the card reader against coin and paper insertion.

Upgrade capabilities: Smart card operated meters use transparent card communication protocol that allows easily upgrading security of the card, or even switching to a different card.

Resistance to aggressive environment: In very high-humidity or very dusty environment contact-type card readers may lose their reliability. In such conditions, contact-less type rechargeable cards may be used. Contact-less cards are being read by the meter through its cover.

Reliability: Card readers can perform up to 300,000 read-write cycles. Even if the cards are charged every week, in 30 years, meter operation requires less than 1,600 cycles. With external casing, physical and electrical insulation, smart card readers are very reliable.

Data transfer: Rechargeable cards can be used for transfer of data between meters and central office. Information about energy consumption is stored on the card and transferred to central office during recharge. Cards are very reliable, with storage time of 10 years. The drawback of rechargeable cards is a necessity to install a large number of recharge' terminals so that customers can conveniently access them.

2.3 Prepaid Meter using two-way fixed network AMR

Meters installed with real-time two-way communication facility, the transaction data is stored on central computer and authorized in the same manner as for credit card terminals. Here security is not at risk as the credit information is stored on the central computer.

2.4 Advantages of Prepaid Meters

Prepaid meters have the following advantages:

- Elimination of billing cost: 1-2% for preparing, printing and mailing invoices.
- Elimination of reading Feasibility
- Elimination of bad debt: 5-12% average, with up to 40% in some developing countries.
- Elimination of payment processing cost: 2-3% cost; 3-5% direct salary of inspectors.
- Interest loss due to check-writing to money-depositing delay: 0.1% per week of mailing and processing period.
- Additional interest on prepaid amounts: Studies show that customers usually prepay for 1-2 months. On average, additional interest is 1% of gross sales.
- Income from multi-tariff: Usually peak time tariff bears 100% surcharge, and nighttime tariff offers 30% discount. With peak

period of 4 hours and night time of 6 hours, income is 4*100%-6*30%=220% day-hour usage. That can increase income of utility by 10%.

2.5 Implementation of Prepaid Meter System

A prepayment metering system replaces the billing system, the reading of meters and the administration of revenue collection. Implementing such a system means a change of mindset, a change in the way the revenue collection is managed, a change in IT procedures, a change in customer service, a change in metering and a change in consumer behavior. All parties need to buy in to the system and understand the benefits.

It is also necessary to plan the implementation of the project in advance. Detailed program, schedules, including resource allocation, distribution of responsibilities and the setting of realistic milestones, are essential for success.

Marketing & Training: Most consumers view anything new with suspicion, particularly if they are not given a choice. The marketing department's task is to put together a package which best suits the consumer's needs.

A prepayment metering system is new not only to consumers but also to all the utility staff and a comprehensive internal training is essential.

Important points to be considered in this context are:

- Installation teams must be trained not only on meter installation but also on training the customers to operate and maintain the meters
- Training of customer service staff to operate the Help Desk, the completion of the registration of new consumers etc.
- Training of vendors, so that they can give the customer good service and create the image the utility wishes to portray.
- Training of the SMS manager, supervisors and operators.

The success of any system relies on the acceptance of all the players within the utility as well as on consumer acceptance. Training and education will assist in communicating the benefits to all staff members.

Maintenance Management: Before the system has been installed, procedures should be in place on how to manage it from a maintenance point of view. The following issues should be considered:

- What happens if a consumer claims to have lost a token? This is more of a problem when using SMART cards than dispensable tokens. All tokens can be re-issued without any security risk, but there is obviously a cost involved. What that cost is, and who bears it, needs to be decided before the start of the project.
- What procedures will be followed if a meter fails? Apart from the actual replacement of the meter, the utility must decide whether it supplies a certain amount of credit with a replacement meter, and whether this credit is charged for. One consumer in South Africa used to complain regularly that his meter was not working, and the maintenance team regularly replaced the meter without testing it. The result was a high maintenance cost to the utility and a consumer who enjoyed the benefit of regular free credit.
- What procedures will be followed if a vending system fails? If the vending stations are situated far apart, a back-up vending station should be available.
- What procedures will be used to back up and archive data? Good housekeeping is required for any database.
- What procedures will be used to avoid the risk of meters being bypassed? (It is difficult to fraud a solid state meter in any other way). Controls should be set up regarding the sealing of meters. For example, will the seals be numbered and the number recorded? Does the installation staff have to sign for seals?
- What are the necessary controls and procedures for collection of revenue from vendors and the transfer of data between SMS and vending station?
- What are the selection criteria for internal and external vendors?

The success of a new prepaid metering installation depends to a very great degree on the thoroughness of the pre-planning phase. This includes seeking acceptance from both consumers and utility staff, and putting in place the necessary procedures for a smooth implementation.

Customer Education: With prepaid meters consumers are in control of their electricity budgets; they decide for themselves how often they wish to purchase electricity and to what value. Customer education assumes top priority for success of the scheme. The points to be considered here are:

- Consumers must know how and where to purchase credit

- Consumers must be able to enter the credit successfully into the meter.
- Consumers must be able to read the meter so they know when they need to re-purchase credit.
- Consumers must know how much credit they have available at any time.
- Consumers must know how to clean the meter.
- Consumers must know what to do or who to contact if they experience problems with the meter

The positive aspects of the system should continually be reinforced. It is important that consumers see prepayment as a benefit rather than a means of punishment.

Brochures should be available at each vending site. Vendors should be trained both in the use of the vending equipment and in the use of the meters and the benefits of the system, so that they are able to promote it.

A television and video should be set up at the vending site if possible. A number of prepayment meter manufacturers provide marketing and training videos, which can be used to show the consumer how to use the system and what the benefits are.

A help line should be set up which customers can use if they are unclear on any issue.

Appendix B: Retail Metering Case Studies

1. Prepaid Vending Lessons learned by ESKOM: A paper by Mr. Hugh McGibbbon, Eskom (June 2002)

2. Duquesne Light Company: AMR Technology is fundamentally changing the way Duquesne Light Company serves its customers: A paper by Ed Finamore, Duquesne Light Company (November 1999)

Eskom
Distribution

PREPAID VENDING LESSONS LEARNT BY ESKOM

UPDEA CONFERENCE
JUNE 2002

Hugh McGibbon
Group Customer Service Manager
Eskom Distribution

1. What were the expectations ten years ago?

In 1991 Eskom had just experienced its first year in Orange Farm, our first major electrification project. I was Deputy Regional Manager in charge of the Orange Farm project and it was ground breaking. We tried concrete poles, and the first one took us three days to erect. We tried covered 11 kV conductor, and burnt our fingers! We spent days debating where the earth leakage unit should go, and I see this specification has been violated since then in the name of cost saving. We never thought of having to audit foolproof meters. Customers were just so grateful to get electricity we never imagined they would try and steal it later. We were so customer focussed that we even specified that the failure of the meter should result in free supply mode, as we did not want to inconvenience the customer, and it was unlikely to happen anyway.

The customer's expectations were quite simple. They wanted access to electricity and it had to be of the same quality as the privileged few in the apartheid era.

Eskom's expectations were mixed. Some missionary zeal went into the ideals of drawing rural disorganised settlements to ordered towns, where electricity was the magnet. Some business orientated managers were adamant electrification should not proceed unless the customers used at least 450 kWh per month within a few years. Other visionary managers simply saw the need of electrifying the nation. As we progressed the main drive was to reduce the cost per connection so that as many houses could be electrified with the money available. This has been hugely successful and the results speak for themselves – over 2,6 million households electrified in a ten year period!

2. Problems that arose due to our inexperience in the prepaid arena.

The classic growth phases were experienced with the electrification drive. Early stages of chaos, excitement and innovation, and later on the control and cost saving stages. We are now at a major review stage. Some of our learning experiences have been as follows:

- One of the biggest errors made was the free supply mode specification whereby the meter supplies free electricity if the meter components fail. We are now busy replacing half a million meters because they have failed and are currently in this mode or may fail soon. It is an ideal opportunity to solve some of the other problems as well.

- Vending controls to restrict fraud are now haunting us. The information needed by complex validations is inaccurate or missing due to poor data discipline over the years.

- In the early days customer connection databases were ad hoc and we seldom terminated customer points when they were washed away in floods, or were discontinued due to violence, and various other reasons. Meter change-outs often went unrecorded. Hence the accuracy is not what we would like and huge efforts are currently underway to rectifying this.

- Revenue protection discipline and activities such as energy balancing was not of high priority in the early 1990's, and again retrofitting this is painful and costly. I feel one of the major latent problems is access to meters for audit purposes. This is one issue the industry must address urgently. Eskom is investigating a plug-in module to fit existing meters that will have an external data outlet or use radio for "drive-by" data acquisition.

- The concept of having to produce a card before being able to purchase electricity and then getting a physical token to transfer the information was short sighted. The justification of illiterate rural people being unable to punch in the 16 digit code sounded good at the time, and may well have been necessary, but growth paths from that were never considered. The major issue here is to convert to an Internet type remote environment of the future.

- The use of smaller vendors to locate vending points close to the customer has led to many challenges. The losses due to vendor fraud and financial risks linked with small vendors are substantial. As a business we cannot continue with this situation, and hence we are consciously moving to larger vendors and national chain stores, where fraud and financial risks are not major issues. To counter fraud and financial risk at the smaller vendor, and to

fully realise the prepaid concept, Eskom is moving to contracts where the vendor pays Eskom up-front for "credit" to vend.

Not all we did was wrong, and none of it seemed wrong at the time! Suppliers have also introduced new technologies and our processes have developed substantially over time. Some of our more positive experiences:

- We have insisted on tracking sales per individual meter. Many debates have taken place in the past and no doubt many will take place in the future over this as it would be much simpler and cheaper to either vend tokens usable in any meter or to install load limiters with fixed charges collected separately. Sanity has always prevailed, as without individual sales tracking, revenue protection is difficult. Customer marketing and Customer Relationship Management also dictate individual sales tracking but we have never capitalised on this.

- We have also always insisted that a prepaid customer should be treated similarly to a billed customer in terms of the data captured such as ID and location. Apart from the customer relationship aspect, customer connection points need to be serviced so we need to find them, we need a legal entity to contract with, and customers may choose to switch between prepaid and billed, and therefore this logic is still sound.

- We now only install keypad meters

- There are many examples of on-line vending systems. Eskom serves very remote areas and it has always been impractical to move to on-line vending, but we are about to start moving in this direction. It opens up many more possibilities for control and collection of arrear payments, collection of connection fees, etc.

- Commission for Vendors does not generate large profits. As the revenue from the prepaid electrification market is less than the costs, the vending by over 1500 agents is seen more as a social service, or to encourage customers to visit their outlet, rather than a normal commercial profitable situation. Eskom has therefore taken the approach of calculating commissions to cover the basic costs and has a range of standard contracts depending on who owns the equipment, who does the consolidation, and who carries the financial risk. Due to the overall loss Eskom makes in this market, we cannot consider increasing these commissions.

3. What does today's customer expect from an electricity supplier?

When a new customer calls our call centre and enquires about getting electricity we do not know at that stage whether prepaid or billed is the most appropriate option – and usually the customer does not know either. Regardless of billed or prepaid, the customer expects immediate information, a quick quote, and then a quick connection. Once they are connected, availability and reliability of supply is important to all. And whether the customer is a declared prepaid customer or a billed "prepaid" customer with a deposit, they expect efficient and easy ways to purchase tokens from their local retail shops. They should not be restricted to only certain vending points as this concept has little meaning in the Internet age. During their life as a customer of ours, their point of delivery may change from prepaid to billed or vice versa.

All customers must be treated the same with respect to some basics, such as the ability to provide the following 4 Customer Service offerings from any of our Contact Centres, via the telephone / SMS / IVR / Internet:

- Electricity Supply Problems
- Accounts, Meters, Payments and Prepaid Cards related services
- Applications and Terminations of Service
- Disconnection's and Credit Extensions

The Vending system has its role to play in the above, and must blend into the overall service range.

4. What does Eskom expect from a Prepaid Vending System?

We do have different processes and systems depending on whether the meter is prepaid or billed, but the following requirements apply to both:

- To identify the customer as a legal entity
- To find the point of delivery for restoration of supply and revenue protection.
- To identify the customer as a member of one of our defined segments / special categories
- To do energy balancing
- To match payments with sales
- To collect arrears and standard charges
- Information to handle customer interactions at Contact Centres
- The need to audit without depending on the customer

- The need for access to our property
- The ability to apply stepped tariffs (eg. a poverty tariff)
- No cash taken by Eskom
- Usage pattern information

Specific requirements on the Vending side:

- Security of vend
- Tamper proof meters
- Simplicity (basic STS vend and token reissue)
- Cost effectiveness (we see perfect real time online solutions, but at a cost that is prohibitive)
- Ideally an integrated solution of vending, banking and reconciliation.
- Global credit management (we have it per CDU, but we need wider controls)

5. What Principles result from the above Customer and Utility expectations?

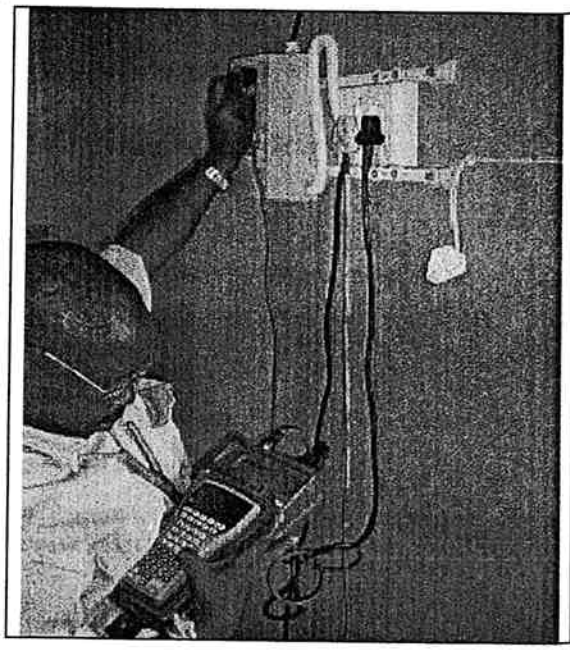
- purchase locations should not be geographically constrained
- sales must be tracked per customer
- third party cash collection
- daily financial reconciliation's must be done
- all Customer Service interactions should be able to be done from any contact centre via phone / SMS / Internet / IVR (information for positively identifying a point of delivery available centrally)
- cater for future feedback from the meter
- minimise losses
- no reliance on the customer for revenue protection (auditing)
- sufficient information to establish a legal contract for the supply of electricity
- need to be able to find the customer

6. Some of the Challenges facing the pre-paid industry

Many of the solutions we seek are already in use by one or other of the many electricity utilities in South Africa. Eskom and the Suppliers need to ensure the new solutions adhere to the above principles and then we need to define a migration path from the current situation to the new solutions.

I have little doubt that the solution must include online vending. This will obviate the necessity of a card carrying information and be compatible with phone / SMS / Web vending. The phone / radio coverage has reached the stage where even the remote Spaza shops should be able to link up electronically. The big question is whether the costs will allow an industry, which is highly subsidised, to go this route.

In the meanwhile we need to take steps to stop the invasion of people's houses. The time is coming when access to houses will stop and then the utility could face a business threatening crisis. It is up to the Engineers to devise the most cost effective migration path that moves the meter outside people's homes and ideally outside their property. This is necessary for access to the meter (assuming it remains the property of the utility) and for audit purposes.



An Eskom Revenue Protection staff member, James Qwabe, checking the pulse of a prepaid meter using an optical eye, which is part of a PEMTI (Portable Energy Meter Test Instrument). Under the present situation, access is required into the customer's house to carry out this work.

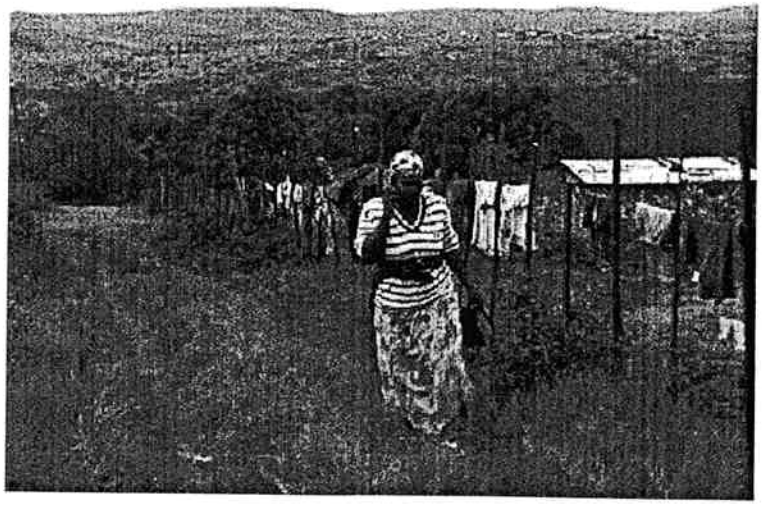
We see tremendous advantages of remote metering for both the delivery of the "token" information and feedback of usage. The question is not whether this is the solution, but when it will become cost effective.

Data integrity will become more important with the new solutions, and the set-up of meters and recording of this information for vending security will have to be streamlined.

Eskom does not claim to know what solutions will be best, and is hence going through a period of piloting and investigation a number of options to take us into the future.

The coming restructuring of the Electricity Distribution Industry in South Africa will bring immense challenges in the prepaid environment that will be far more complex than the billed environment. With a myriad of propriety meters, mix of technologies and degrees of outsourcing across Eskom and Local Authorities, we need a common vision and common standards such that we can move towards these over the next ten years.

In a few years time I am sure we will be installing radically different vending and metering solutions to the ones we started with in Orange Farm. However it has taken us over 10 years to install the current base of over 2,6 million prepaid meters, and so we will take small incremental steps over the next 10 years to move totally to the new concepts we are discussing today. We are busy preparing a blueprint to direct our path into a future where our customers will be using new technologies. It is a daunting prospect, but it will also hold many opportunities. It will be an exciting next ten years!



ITRON®

Delivering the Value of Information to Utilities

November 1999

Duquesne Light Company:

Itron Network Delivers Value Far Beyond Meter Reading

"AMR technology is fundamentally changing the way Duquesne Light Company serves its customers."

— Ed Finamore, General Manager Business Development and Metering Technology Duquesne Light Company

Project

On January 15, 1996, Itron Inc., a leading provider of automatic meter reading (AMR) equipment and services to the utility industry, signed a contract with Duquesne Light Company to provide the Pittsburgh-based utility with territory-wide energy information services for a period of 15 years.

Client

Duquesne Light Company is an electric utility serving nearly 600,000 customers in an 800-square-mile service territory that includes the Pittsburgh metropolitan area and much of Allegheny and Beaver counties.

Objectives

To prepare for growth and success as an energy provider for the 21st century, Duquesne Light Company was seeking an AMR solution that would improve customer service across all segments, reduce meter reading costs, improve operational efficiency, and prepare the utility and its customers for deregulation and customer choice in Pennsylvania.

Solution

The most distinguishing aspect of the Itron AMR system at Duquesne Light Company is not necessarily the technology itself, but the integration of different meter reading technologies into a single data collection and management solution. To provide the most cost-effective solution for different customer segments and service levels within Duquesne's service territory, Itron deployed a system that brings together fixed network, telephone and mobile AMR technologies into an integrated solution that allows the data to be collected, used and distributed as if it came from a single source. This approach enables Duquesne Light to employ the most cost-effective level of data collection functionality it requires for each customer segment (including C&I) and each type of service environment — no more, no less. Data from all collection sources is delivered to Duquesne's Customer Information System every day in a single integrated file. The Itron Fixed Network and telephone-based AMR systems support a range of advanced functionality, including consumption reads; on-request reads; time-of-use, demand and interval/load profile reads; outage detection and restoration reporting; and tamper detection.

C&I Covered

In today's marketplace, deregulation, technological advancement and customer demand are redefining and expanding the boundaries of the commercial and industrial customer segment. Steadily increasing numbers of smaller companies and businesses are seeking more competitive rates and value-added services from their energy provider. To provide its C&I customers with a superior level of service in this competitive environment, Duquesne Light also required a scalable C&I solution to support advanced services such as interval data collection, load profiling, customized billing and rate development, and Internet access to data. To meet this objective, Itron combined its MV-90 data collection and analysis software with the MV-COMM high-speed communications processor and Telenetics Corporation's Omega communication interface equipment to collect, process and analyze advanced C&I metering data on an

Client Profile

Client:
Duquesne Light Company

Location:
Pittsburgh, Pennsylvania

Type:
Electric Utility

Service Area:
800 square miles of southwestern Pennsylvania, including the greater Pittsburgh metropolitan area, and much of Allegheny and Beaver counties

Area Population:
1.5 million (nearly 600,000 direct customers)

Service Area Profile
Extremely diverse: includes residential, commercial and industrial accounts ranging from heavily saturated urban areas to less-saturated suburban environments, to isolated rural pockets.

"This advanced outage detection capability will be an important component of Duquesne's success as a distribution company and will support performance-based ratemaking requirements for system reliability."

— Ed Finamore
Duquesne Light Company

unprecedented scale. Currently, Itron is collecting and delivering interval data from more than 14,000 solid-state commercial and industrial metering points in the Pittsburgh area, using both telephone and cellular communication links. Duquesne expects to increase that number to approximately 28,000 C&I meters.

Financing

When Duquesne Light selected Itron Inc. to provide a fully integrated AMR system, the utility also chose to fully outsource the project by having Itron install, own, operate and maintain the system for a period of 15 years. By selecting a fully outsourced financing option, Duquesne chose a "pay-for-what-you-get" structure that featured a graduated schedule of payments and substantial non-performance protection. Compared to a direct-purchase or lease-financing arrangement, outsourcing provided Duquesne Light with a low-risk, low-initial-cost financing option that freed the utility from the burden of a large, front-end capital expenditure. And by contracting with Itron to install, operate and maintain the system for the first 15 years, the utility avoided additional training and human resource costs.

Regulatory Climate

Although Pennsylvania is considered one of the "early states" in pursuing deregulation, regulatory issues were not necessarily at the forefront of Duquesne's initial decision to deploy an advanced AMR system. Rather, the drivers behind the utility's decision to deploy were largely operational: improve meter reading operations and customer service. But as the regulatory climate in Pennsylvania evolved, Duquesne is discovering that the information delivered by the Itron AMR system is critical to successfully managing the operational demands and market opportunities presented by customer choice. Today, Duquesne is equipped to perform such tasks as end-of-service reads for customer switches, new supplier pickup reads, and energy reconcilement and market settlement functions associated with customer choice. By deploying a territory-wide AMR system from Itron, Duquesne not only has achieved its initial operational objectives, but also is using the information AMR delivers to position itself for success in a competitive marketplace.

Milestones

Installation of Itron ERT® meter modules at Duquesne began in April 1996. By October 1996, Itron met its first performance milestone by completing and successfully reading the initial 5,000 meters over the Fixed Network. By August 1997, Duquesne Light Company was billing approximately 105,000 accounts using daily read data provided by Itron's Fixed Network, and had installed a total of 520,000 meter modules in the Pittsburgh area.

During network installation, Itron also employed Mobile AMR technology to provide cost-effective monthly consumption reads for more than 400,000 meters. As the network expanded, Itron successfully switched large numbers of meters that had been read using Mobile AMR technology to the Fixed Network for daily reads. Because Itron meter modules are fully integrated and compatible with all types of Itron radio-based AMR technology, switching those meters to the Fixed Network required no additional equipment installations, meter module modifications or additional costs. In October 1998, Itron announced that its Duquesne Network had successfully met the Phase II milestone of its deployment by delivering a total of more than 465,000 daily reads. In January 1999, installation was completed and the system began full commercial operation.

Current Status

Today the Itron AMR system at Duquesne Light is collecting a total of more than 585,000 reads for billing, including 440,000 daily reads over the Fixed Network; nearly 46,000 daily reads from customers whose meters are equipped with Itron telephone-based meter modules, and an additional 80,000 monthly consumption reads using Itron Mobile AMR technology from customers in outlying areas of its service territory who require only monthly reads. The system also is collecting interval data from 14,000 commercial and industrial customers using MV-90.

Itron Technology Deployed:

- 520,000 Electric ERT modules
- 46,000 Itron Telephone-based AMR modules
- 2 Master Station Host Processors
- 50 Network Control Nodes (NCNs)
- 9,964 Cell Control Units (CCUs)
- 4 Genesis Itron Host Processors
- 5 DataCommand Units (Mobile AMR)
- MV-90
- MV-COMM
- MV-WEB
- MV-PBS

Functionality Profile:

- Monthly Reads
- Daily Reads
- Time-of-Use
- Load Profiling
- Outage Detection and Restoration Reporting
- Real-time Pricing
- Power Quality Event Monitoring
- On-request Reads
- Daily Tamper Reporting
- Customized Billing for C&I Customers
- Internet Data Access for C&I Customers

Benefits

In selecting Itron to install and operate this AMR system, Duquesne Light became the first utility to integrate meter reads from Fixed Network AMR, Mobile AMR and Telephone-based AMR into a seamless information gathering network to cover residential, commercial and industrial accounts over a large and diverse service area. When viewed as a whole, Itron's fully integrated AMR system provides Duquesne Light with the flexibility and functionality required to cost-effectively achieve its business objectives of increased operational efficiency, improved customer service, and preparation for success in a deregulated energy marketplace

Meter Reading and Customer Service

With the system installed and in full commercial operation, Duquesne is achieving its goals of improved meter reading and customer service. Meter reading staff has been reduced while inaccurate or estimated meter reads, and the resulting operational difficulties they tend to create, have been reduced significantly. As anticipated, these benefits have extended through Duquesne's billing and customer service operations in the form of improved billing accuracy, reduced call center traffic, improved customer complaint resolution, and reductions in field visits for special reads and billing complaint investigations. The system also provides an efficient solution for off-cycle meter reads associated with beginning- and end-of-service orders.

Distribution-Side Benefits

In addition to the meter reading and customer service benefits, Duquesne Light is finding that the AMR system delivers significant value on its distribution side. By collecting daily reads from the vast majority of its customers, Duquesne has been able to significantly improve its load forecasting accuracy. This, in turn, should help the utility protect gross margins by minimizing expensive spot-market energy purchases.

Duquesne Light Company also is completing the second phase of its outage-detection system, which will integrate data from both ERT and telephone modules at the customer level, Cell Control Units at the neighborhood level, solid-state meters at the C&I customer level and SCADA, and deliver it all to Duquesne's Transmitton outage management system.

So instead of relying on only 1,500 outage detection points on the current SCADA system, Duquesne now has a network of well over a half million detection points spread vertically and horizontally throughout the distribution system. This enables Duquesne to improve system reliability and customer service by quickly identifying and responding to outages at a very localized level. The result is improved field crew management, faster restoration times and improved customer service.

"By integrating Transmitton's decision support system with the Itron fixed network, Duquesne is in the process of deploying what we believe will be the most advanced outage detection system available to utilities today," said Ed Finamore, general manager for business development and metering technology at Duquesne Light Company. "This advanced outage detection capability will be an important component of Duquesne's success as a distribution company and will support performance-based ratemaking requirements for system reliability in Pennsylvania's deregulated environment."

Managing Market Change

On January 1, 2000, all electricity customers in Pennsylvania — commercial, industrial and residential — will be able to choose their energy supplier. This historic change represents both significant operational challenges and important opportunities for Duquesne Light Company. AMR technology is a tool that will help the utility successfully manage both. For instance, one of the most important uses of daily reads gathered over the network is energy supplier reconcilement. In a deregulated environment, in which customers have their choice among multiple energy suppliers, frequent data collection is a tremendous advantage.

For instance, in Pennsylvania, each electricity supplier maintains ultimate responsibility for forecasting their respective loads. However, most energy service providers do not currently possess resources to perform accurate load forecasting, which can expose both supplier and distributor to significant economic risk. By using AMR technology to collect daily and/or interval reads, Duquesne has the information it requires to accurately profile how much electricity is put into and taken from its distribution system. In turn, Duquesne is able to provide forecasting, balancing and reconcilement information to third-party energy service providers, who are, in effect, new customers for Duquesne's data in Pennsylvania's deregulated marketplace.

(continued on next page)

Benefit Profile:

- Meter reading cost reductions
- Reduction in meter re-read costs
- Reduced estimated reads
- Improved billing accuracy
- Improved customer service
- Improved high-bill complaint resolution
- Reduced call center traffic
- Reduced response time for off-cycle reads
- Daily reads improve forecasting accuracy
- Daily reconciliation and load balancing
- Preparedness for retail competition/customer choice
- Supports final reads for customer choice
- Improved outage restoration time
- Improved field crew management
- Improved reliability and customer service
- Forecasting and reconcilement services for ESPs
- Assists in meeting performance-based rate-making criteria
- Enables Internet access to load data for C&I customers
- New value-added services opportunities
- Alternate reading capability in case of long-term network outage
- AMR coverage for all environments (urban, suburban, rural)
- Supports all customers (residential, commercial, industrial)

PREPAID VENDING LESSONS LEARNT BY ESKOM

Contents

Synopsis

It has been over 10 years since Eskom started seriously with its electrification drive which has seen over 2,6 million prepaid customers connected to the grid. This paper compares how the expectations of the customer and Eskom have changed over this period. It looks at the mistakes made and positive changes that have taken place. It explores the challenges currently facing the prepaid electricity industry – an industry that could disappear as we know it if these challenges are not met.

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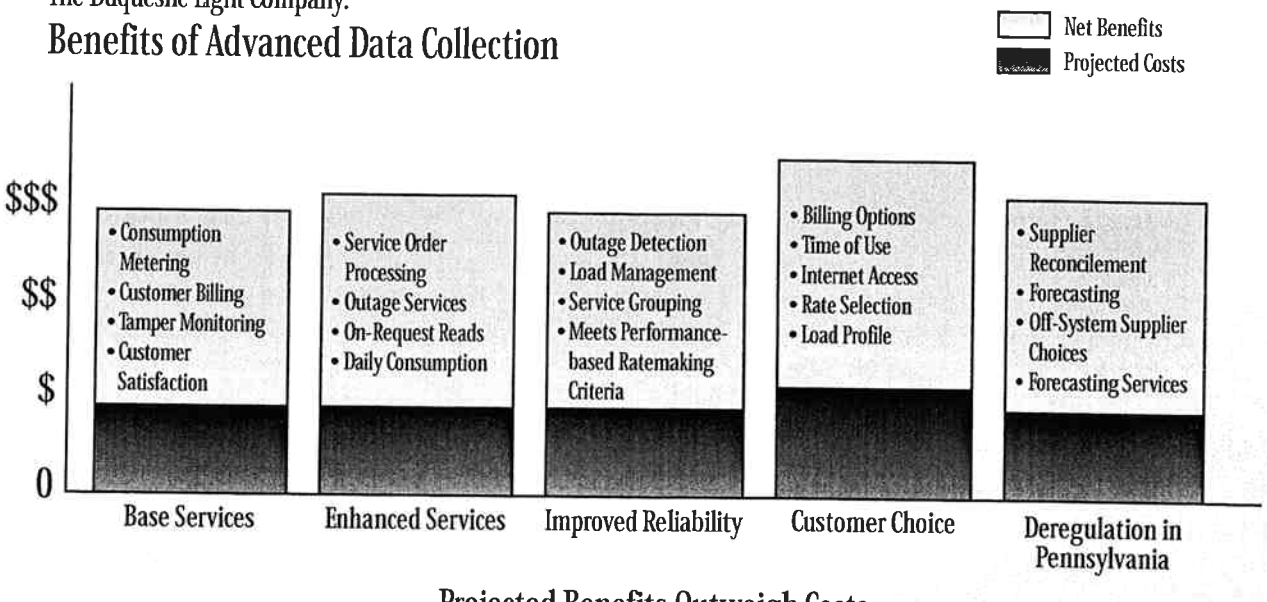
The Duquesne Light Company:

Benefits of Advanced Data Collection



Projected Benefits Outweigh Costs

Value-Added Opportunity

In a competitive market environment, customer service will be the critical standard for measuring distribution company success. Duquesne Light is just beginning to explore the opportunities advanced network data collection represents in the area of value-added services.

During 2000, Duquesne plans to launch a third-party outage notification pilot for approximately 200 customers. Under this program, customers will pay Duquesne a monthly service fee for outage notification services. Duquesne Light is also set to begin offering selected commercial and industrial customers Internet access to their load data using Itron's MV-WEB software. This pilot project, which will be used to gauge the demand for data access services, will provide commercial and industrial customers with on-line access to their load profile data, giving them information they need to manage their energy costs more effectively than ever before.

In addition to some of the service offerings already mentioned, such as outage detection and notification services, customized billing and Internet access to data, advanced data collection can support a whole new frontier of value-added services such as customized rates, selectable billing dates, summary billing, aggregation and disaggregation, energy consulting services and more. All this is made possible by the information the system delivers.

Conclusion

Duquesne Light's AMR installation provides compelling testimony to the value of information in today's energy marketplace. In addition to increasing meter reading efficiency and improving customer service, the information collected daily from the Itron network delivers operational and strategic value throughout Duquesne's operations, including distribution, marketing and business development, and successful management of retail competition and customer choice. As Duquesne Light Company is discovering, the true value of AMR technology can be found in the information it delivers.

"In comparing the way Duquesne Light ran its meter reading operations a few years ago to the way it operates today, the difference is quite remarkable," said Finamore. "AMR technology is fundamentally changing the way Duquesne Light Company serves its customers."

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Appendix C: Transforming Meter Data into Knowledge

Transforming Meter Data into Knowledge [1]

Electric and gas utilities have a tremendous amount of data about their customers locked away in multiple metering systems across the enterprise. Typically, companies use this data in organizational silos such as customer service, load research and forecasting, and, of course, billing. The successful utility of tomorrow will leverage this data throughout the enterprise.

What Is Meter Data Management?

Meter data management is the process of collecting, analyzing and applying meter data to facilitate decision-making. Data collection is the capture of measurements as the commodity moves through the value chain. Analysis is the conversion of the meter data into information that can be used to serve customers, measure profitability, forecast load, and manage risk. Application is getting this information out to groups both inside and outside of the organization to use in the decision-making process.

Industry Forces

External factors such as the Federal Energy Regulatory Commission's Standard Market Design ("SMD") proposal, the softening of the wholesale energy market, and the failure of deregulation are influencing the energy value chain in many ways. In response to these forces, utilities are pursuing diverse tactical initiatives such as risk management, demand response, and cost containment. These initiatives require high-quality information about customer usage patterns to deliver value. These developments are forcing utilities to ask some tough questions.

Meter Reading

Will automated meter reading ("AMR") technology help reduce costs?
How can meter reading improve its support of downstream business processes such as billing, demand response, and outage management?
How can meter-reading technologies be best deployed to cover the utility's service territory?

Customer Service

How can the utility best serve its largest customers?
How can the billing system support more complex rate structures?

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[1] By Ed Thomas, Senior Energy Consultant, Itron (published in June 2003 in Energy Pulse).

What can customer service do to satisfy customer requests for information?
Can large account managers get the data that they need to support their customers?
What service options can the utility offer to the emerging mid-size commercial and industrial ("C&I") segment? Marketing
How can the utility more effectively target customers for programs such as demand response and load control?
If the utility offers new products and programs, how can success be measured?
How does the organization measure customer and product profitability?

System Operations

Does the utility have the tools to manage congestion and perform accurate system forecasts?
What steps can the utility take to minimize unexpected settlement charges from the market operator?
How does a utility unlock the value of data in its energy management system?
How can the organization use actual usage data to plan for transmission and distribution construction and maintenance?

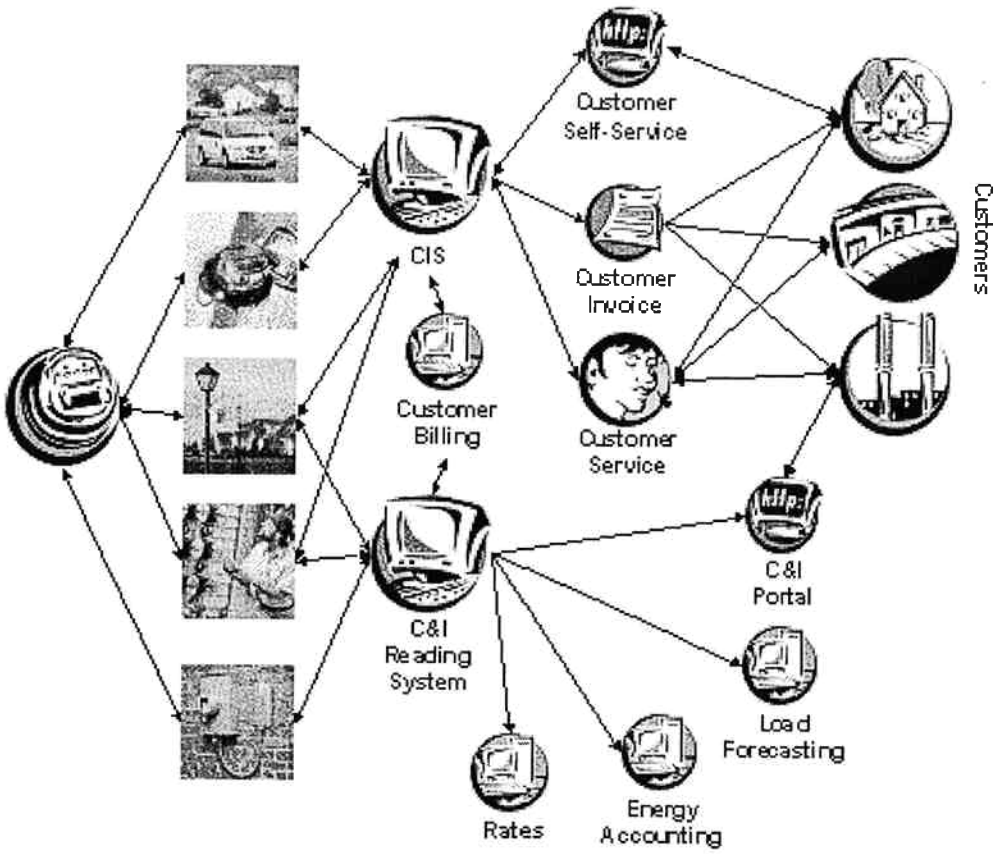
Energy Accounting

Is it possible to reduce the amount of time to perform wholesale energy accounting and market settlement?
Can the utility interact with wholesale entities in an optimal manner?

Information Technology

How can a utility reduce the cost to operate and support its enabling systems?
Does the utility's application architecture hinder or enable process integration?

The answers to some of these questions lie buried in the utility's systems and processes in the various forms that the organization stores meter and other operational data. Meter data management processes and technology can be an enabler to help a utility answer the questions. The following table illustrates the role of meter data management as an enabler of the enterprise:



Current State of Meter Data Management in the Utility Industry

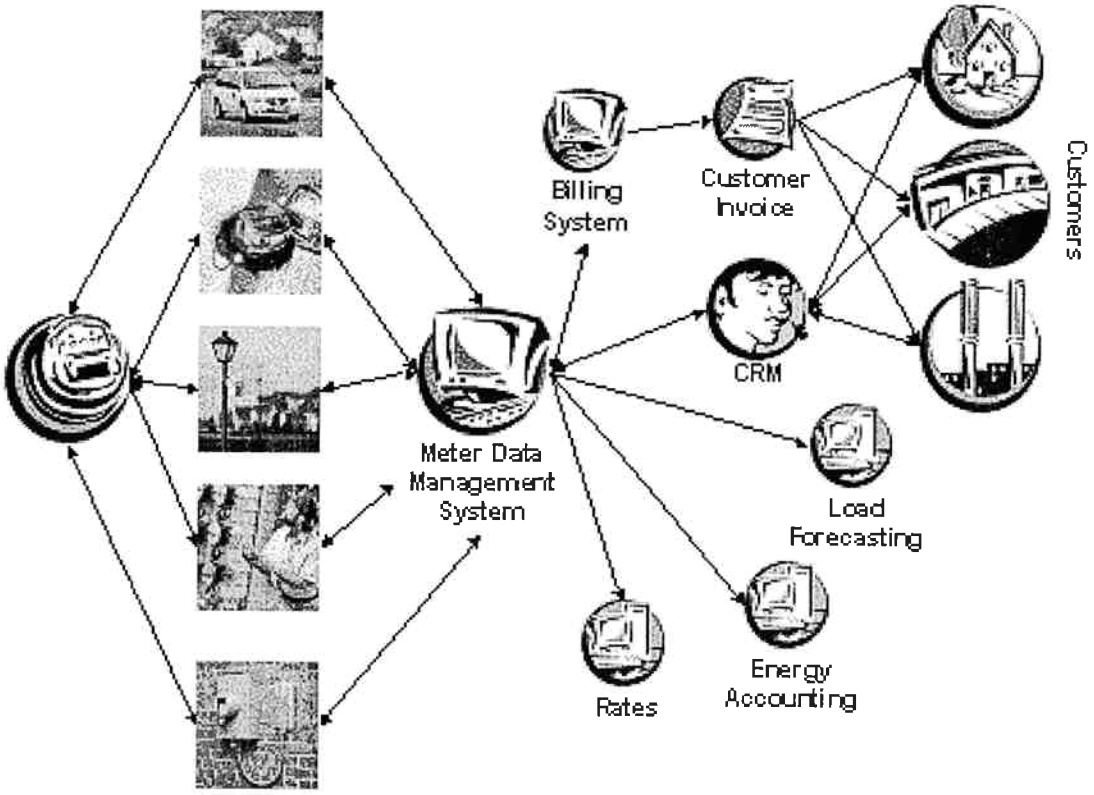
The current state of meter data management can be described as disjointed at best. Due to the inherent limitations in collection technologies and geographic constraints, utilities cannot take a "one-size-fits-all" approach. These limitations have led utilities to deploy one system for the mass market and another for the large C&I segment. Since this data's primary use is for billing, mass market metering data is typically resident within the utility's customer information system. Large C&I metering data and its load profile data are typically managed in an application such as MV-90 or in an internally developed data repository. The figure above illustrates this disjointed architecture.

These processes and the underlying technologies lead to performance problems in metering and downstream business processes. Utilities tend to build organizational silos between the meter reading organization and its customers. This organization leads to high error rates and multiple hand-offs. In addition to organizational issues, these fragmented processes result in poor decision making across the enterprise as a result of the use of estimates and of outdated versions of meter data. Also, the lack of integrated meter data management processes can result in a higher

degree of customer dissatisfaction through billing errors. In the end, current meter data management processes cost more to the utility to execute and maintain than they should.

Future State of Meter Data Management

The vision of meter data management is based on an integrated data repository. The meter data management system becomes the hub for the collection, translation, and application of metering data as used inside and outside the organization. This repository should integrate the mass market and C&I meter-reading systems and SCADA measurement systems into one vendor-independent data store. The downstream processes and systems that use this data should access the data through standard application interfaces. The following figure illustrates this vision.



As one can see from the figure above, the future vision extends the value of meter data throughout the enterprise. The value of this extension includes the following:

- Central data storage for meter data regardless of source (residential, large C&I, or SCADA) and of collection method (AMR or handheld)
- All business processes that require meter data use the same data, therefore, reducing errors in analysis and decision making
- Customers can access their meter data over the Internet to understand their usage patterns and its impact on their bill
- Minimal point-to-point system interfaces through robust systems integration and an open, standards-based architecture
- Data generated in one organizational unit (e.g., load forecasting) can be easily used by another unit (e.g., marketing)

The meter data management system is the core enabler of this vision. The meter data management system must be able to extend the value of metering data to the enterprise via an open application architecture based on standards. The system should perform complex calculations and aggregations with a user-friendly interface. To address external market relationships, the system must produce meter data in approved market format. Since the MDM system is the system of record for all meter data, it must provide robust versioning, auditing, and security capabilities to provide a high degree of data integrity.

As the future state of meter data management continues to evolve, key themes are emerging across process and technology. Some of these themes include the following:

- As energy markets continue to mature, settlement requirements may require more frequent data collection.
- In some cases, utilities will need to integrate data collection across its value chain.
- The emergence of risk-based pricing models (e.g., real-time pricing and time-of-use) will challenge legacy systems.
- Customers, particularly C&I customers, will demand more reliable and timely access to usage data, specifically load profile data.
- Utilities will use meter data management systems to measure the degree of compliance and effectiveness of demand response programs.
- Restructuring utilities will see high value in the integration of schedule, real-time SCADA, and revenue-quality data as an input into the settlement reconciliation process.

A successful meter data management deployment should integrate processes and break down organizational silos. All downstream processes

can obtain timely and accurate revenue-quality data from the utility's meter reading systems. Marketing can gain greater insight on program effectiveness and customer profitability through access to meter data. System Operations provides candidates for demand response programs to marketing. Energy Accounting needs to integrate schedules, forecasts, SCADA, and metering data to provide more accurate settlement data to the market operator.

The Bottom Line

Effective meter data management means getting the right data to the right user enabled with the right tools to make the decisions that optimize the delivery and use of energy. The potential benefits to a utility regardless of industry value chain segment are enormous.

- Utilities can increase profitability through process efficiencies, reduction in errors, and better information about energy usage.
- Due to improved data consistency and reduced data latency, people make better decisions that originate from metering data.

An integrated meter data management solution can improve customer service by reducing billing errors, improving the quality of customer information, and responding more quickly to customer requests.